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DESIGNED TO INFORM LEADERS IN INDUSTRY, GOVERNMENT, AND EDUCATION, WHOSE RESPONSIBILITY INCLUDES AWARENESS OF ENGINEERING MANPOWER DEVELOPMENTS, THIS BULLETIN REPORTS A STUDY CONDUCTED BY THE ENGINEERING MANPOWER COMMISSION OF ENGINEERS IN THE ARMED SERVICES. THE WORK OF THE COMMISSION IS TO ASSURE THE MOST EFFECTIVE UTILIZATION OF ENGINEERING MANPOWER IN MEETING THE NATION'S NEEDS. THIS BULLETIN REPRESENTS A PRELIMINARY STUDY RATHER THAN A COMPREHENSIVE ANALYSIS. RELATIVE TO THE TOTAL SITUATION, THE BULLETIN REPORTS 34,000 ENGINEERS ON ACTIVE DUTY, BUT THIS DOES NOT INCLUDE SUCH NON-UNIFORMED SERVICES AS THE COAST GUARD, COAST AND GEODETIC SURVEY, OR PUBLIC HEALTH SERVICE. RESERVE UNITS WERE NOT INCLUDED, NOR WERE ENLISTED MEN IN THE SERVICES. GENERALLY, AT THE BACHELOR'S LEVEL, THERE IS AN APPARENT SURPLUS OF ENGINEERS ON DUTY AS COMPARED TO DESIGNATED REQUIREMENTS. ON THE BASIS OF ADVANCED DEGREES, THERE IS A DEMAND FOR 15,500 MASTER'S AND DOCTOR'S DEGREE ENGINEERING GRADUATES, BUT ONLY ABOUT 8,500 QUALIFIED MEN TO FILL THE NEED. BEYOND THESE GENERAL OBSERVATIONS, THE BULLETIN DISCUSSES (1) ENGINEERS IN THE AIR FORCE, (2) ENGINEERS IN THE ARMY, (3) ENGINEERS IN THE NAVY, (4) CIVIL ENGINEERS CORPS, (5) SHIP ENGINEERING, (6) ORDNANCE AND AERONAUTICAL ENGINEERING, (7) OTHER SPECIAL GROUPS, (8) GENERAL LINE SPECIALISTS, AND (9) ENGINEERS IN THE MARINE CORPS. THIS DOCUMENT IS ALSO AVAILABLE AT NO COST FROM THE ENGINEERING MANPOWER COMMISSION, 345 EAST 47TH STREET, NEW YORK, NEW YORK 10017. (DH)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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ENGINEERING MANPOWER BULLETIN

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This is the ninth in a series of Bulletins designed for leaders in industry, government, and education, whose responsibility includes an awareness of developments in engineering manpower. The Bulletins attempt to present important data or significant trends within the confines of a document which can be read quickly. In this issue we report the initial findings of a study of engineers in the armed services being conducted by the Engineering Manpower Commission as part of its program to assure the most effective utilization of engineers in meeting national manpower needs.

JOHN D. ALDEN, *Executive Secretary*
Engineering Manpower Commission
of Engineers Joint Council

ENGINEERS IN UNIFORM

The Engineering Manpower Commission and the Armed Forces

The employment of engineers as uniformed members of the armed forces is a subject that is not well understood on the civilian side of the engineering community. Engineers in uniform are seldom counted in studies of the nation's engineering manpower supply and demand. Engineering requirements in the military services are little known outside of specialized circles. Indeed, there seems to be a feeling among many civilians that engineers in uniform are doing second rate engineering at best.

The Engineering Manpower Commission of Engineers Joint Council has throughout its existence worked closely with the Department of Defense and the Selective Service System as part of its mission to assure the effective utilization of engineers in the national interest. It is now engaged in a thorough study of engineers in the armed forces. This bulletin represents a preliminary look at this area, rather than a comprehensive analysis of all aspects of engineering in the military. It summarizes the numbers of engineers serving as officers in the armed forces and the general areas in which they are employed. All statistical data for this report were provided by the military services themselves through the coordinating office of the Assistant Secretary of Defense (Manpower). Figures are considered representative of the situation existing throughout 1966 and 1967. Some interpretation and regrouping has been done to condense the various specialty designations used by the services into a format more suitable for analysis and presentation.

The Total Picture

As reported by the military services, more than 34,000 engineers are identified as serving on active duty. Detailed figures are tabulated on page 3 of this bulletin. This, however, is not the complete picture. No figures have been given for the Coast Guard, Coast and Geodetic Survey, or Public Health Service, all of which are uniformed services with certain military obligations, especially in wartime. No effort has been made to identify engineers in reserve status. Even more significant is the absence of data on engineers serving as enlisted men in the Air Force, Army, and Navy, all of whose figures are for officers only. While it is probable that a majority of engineering graduates end up in officer programs, there may be a substantial number in the enlisted ranks, especially as Selective Service inductees in the Army.

If we estimate 4,000 engineers in service but not counted, this means that approximately 38,000 engineers are in uniform. Other EMC surveys indicate that about 9% of this year's engineering graduating class went into the armed forces, and more than 500 of the engineering degrees awarded in 1967 were to career officers on active duty. By any measure, the military services are major users of engineering manpower.

Requirements Versus Supply

While practices vary widely in the different services, the most common procedure is to identify engineering requirements at advanced degree levels only. A bachelor's degree is a preferred qualification for all commissioned officers, and engineering students are highly regarded in ROTC programs for all three services. With many engineers thus serving in general line duties, there is an apparent surplus of engineers on duty as compared to designated requirements. The Army identifies about 1,700 positions as "validated requirements" for engineers but has over 9,000 engineers in service. The Navy lists requirements for some 10,900 engineers and related scientists, but has nearly 9,000 engineers and 11,000 science graduates available to fill them. The Air Force reports that most of its 14,000 engineers are assigned to career utilization fields, but identifies only 5,000 advanced degree requirements in these areas. Only 171 of the 1,668 engineering graduates in the Marine Corps have engineering as a primary occupational specialty.

On the basis of advanced degree requirements, how-

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ever, the services are decidedly short-handed, with positions for more than 15,500 master's and doctor's degree graduates in engineering and related sciences, but fewer than 8,500 men with these qualifications on active duty. This means that nearly half of the requirements must be filled by people with less than a master's degree.

For the engineer with a bachelor's degree, then, the services pose something of a dilemma. His alternatives are to fill a specialist job normally requiring an advanced degree, or to serve in a general line position with little or no real engineering content. Those fortunate enough to be assigned to specialized enginering work will find a variety of interesting opportunities in some of the programs described below.

Enlisted Men

The number of enlisted men with engineering degrees is not available for any of the services. Since neither the Air Force nor the Navy is currently using draftees, there is little expectation that many engineers would be found in the enlisted ranks of these services except by their own choice. The Army may be a different case. It does, however, have a program for using some qualified enlisted personnel as scientific and engineering assistants, as described below.

Engineers in the Air Force

During 1966 the Air Force had about 14,000 engineering graduates serving as officers. Most of these engineers are assigned to career utilization fields in R & D management, development engineering, system program management, and civil engineering. There are also a number of engineers assigned to the electronics and maintenance engineering career area, mainly engaged in the management and supervision of work in these technical fields.

Officers with advanced engineering degrees are almost exclusively utilized in the above fields during their careers. Some are given intervening teaching assignments at the Air Force Academy or Air Force Institute of Technology.

The numbers of engineering graduates on duty during 1966, broken down by academic specialty and degree level, are indicated in the table on page 3.

The Air Force procurement program for new officers with engineering degrees in fiscal 1968 calls for 941 in development engineering and 300 in civil engineering. About half will come from ROTC programs in civilian colleges and the remainder from officers' training schools operated by the Air Force.

The Air Force fiscal 1971 projection of advanced degree requirements in engineering includes the following for all utilization fields:

Utilization Field	Master	Doctor	Total
R & D, Development Engineering, Systems Engineering	2,321	261	2,582
Civil Engineering	629	18	647
All Others	1,621	115	1,736
TOTALS	4,571	394	4,965

Engineers in the Army

Engineering requirements in the Army are centralized in two major program areas. The Army Corps of Engineers has a current strength of about 7,000 officers, many of whom hold engineering degrees. The work of this Corps is strongly oriented toward construction, both military and civilian. Its activities on river, harbor, and water control projects are well known to the public.

In addition, the Army Officer Special Career Programs include four areas which require advanced degrees in engineering or related disciplines, as follows:

Program	1967 Strength
Atomic Energy Specialist	524
Research and Development Specialist	180
Operations Research and Systems Analysis Specialist	141
Automatic Data Processing Specialist	271
TOTAL	1,116

Engineering degrees are considered desirable for officers being commissioned in the Signal Corps, and in the Ordnance, Chemical, Transportation, and Artillery branches. However, none of these groups specifically requires engineering degrees for any positions.

The Army identifies its specific engineering degree requirements only at the master's and doctor's degree levels, with total "validated requirements" of 1,728 in March 1967. The Army Advance Degree Program enables qualified and selected officer volunteers to attend civilian colleges and universities and earn advanced degrees in approved fields consistent with the needs of the service. Officers educated under this program can expect to be assigned to a position requiring the knowledge gained.

Because of the widespread use of engineering graduates in general positions, as described above, the number of engineers on duty as officers in the Army is much greater than the validated requirements. The table on page 3 shows these figures for the various degree levels.

Engineers who are drafted into the Army as enlisted men have only limited opportunity to serve in engineering-related capacities. Unless draftees agree to an extended period of enlistment, they are not eligible for officer candidate programs and thus cannot achieve any of the positions previously described as requiring an engineering degree. The enlisted Scientific and Engineering Assistants Programs provides for the identification, selection, and utilization of men in the following engineering specialties:

Electrical-Electronic Engineering Assistant
Mechanical Engineering Assistant
Civil Engineering Assistant
Chemical Engineering Assistant
Mathematics-Statistics Assistant

At the present time there are about 1,200 positions identified under this program. It is not known how many men with engineering or science degrees are serving as enlisted men in the Army, whether as voluntary enlistees or as Selective Service inductees. In all probability there are more than 1,200. Therefore, those in excess of the 1,200 designated positions are most likely serving in capacities having little or no relation to their engineering education.

Engineers in the Navy

The Navy has a number of officer programs in which engineering degrees are specifically required. Officers in these categories are called "specialists" and can expect to serve in engineering positions at a professional level throughout their naval career. In four specialties—ship engineering, ordnance engineering, aeronautical engineering, and civil engineering—position requirements have been established at the bachelor's, master's, and doctor's degree levels.

In other specialized corps and in the general line of the Navy engineering degree requirements are specified at the master's and doctor's degree levels only. Such officers in the unrestricted line are known as "subspecialists" and can expect to be assigned to duties involving their specialty for about one-third to one-half of their service career, alternating between regular duties at sea or ashore.

About 400 officers are serving in designated engineering positions although their highest degree is in some other field. In these cases the men involved have a lower degree in engineering or sufficient engineering background to qualify for the engineering designation held. Combined totals are shown in the table below.

Civil Engineer Corps

The group which is probably most familiar to the general public is the Civil Engineer Corps, which includes the renowned Seabees or Construction Battalions. Officers in this corps are responsible for the planning, design, construction, maintenance, and operation of public works and utilities on the Navy's shore bases at home and abroad. Engineering skills in many specialties are required, with

ENGINEERS IN THE ARMED FORCES (1)

Academic Field	Air Force				Army				Navy and Marine Corps(2)				All Services All Degrees
	Bachelor	Master	Doctor	Total	Bachelor	Master	Doctor	Total	Bachelor	Master(3)	Doctor	Total	
Aerospace	1885	1089	25	2999	124	174	2	300	495	378	2	875	4174
Agricultural	156	8	0	164	129	7	0	136	51	1	0	52	352
Chemical	333	32	4	369	513	66	27	606	345	10	3	358	1333
Civil and Architectural	1366	247	15	1628	1744	963	12	2719	891	220	7	1118	5465
Electrical and Electronics	2847	735	32	3614	1474	448	22	1944	1861	441	8	2280	7838
Engineering Sciences	125	15	3	143	13	10	0	23	NOT SEPARATELY REPORTED				166
Environmental Health & Safety	13	5	0	18	3	19	0	22	6	16	0	22	62
General	260	11	0	271	NOT SEPARATELY REPORTED				NOT SEPARATELY REPORTED				271
Industrial	913	335	2	1250	532	162	1	695	299	82	0	381	2326
Mechanical	2272	333	8	2613	1185	277	17	1479	1282	150	1	1433	5525
Metallurgical and Materials	143	20	10	173	146	25	3	174	72	7	4	83	430
Mining(5)	102	7	0	109	64	3	0	67	33	0	0	33	209
Naval Architecture and Marine	NOT SEPARATELY REPORTED				6	4	0	10	39	326	5	370	380
Nuclear	88	153	10	251	24	100	5	129	48	92	1	141	521
Ordnance	NOT SEPARATELY REPORTED				1	0	0	1	252	415	6	673	674
Petroleum	INCLUDED WITH MINING				76	31	0	107	44	8	0	52	159
Systems	10	50	1	61	6	10	5	21	NOT SEPARATELY REPORTED				
Textile	87	4	0	91	105	14	0	119	33	13	0	46	256
Other Engineering	485	68	0	526	240	95	0	335	490	63	0	2221(2)	3082
Aerology(4)	NOT REPORTED				NOT REPORTED				86	46	1	133	133
Architecture (4)	NOT REPORTED				267	8	0	275	97	2	0	99	374
Science, Management, etc.(4)	NOT REPORTED				NOT REPORTED				136	58	13	207	207
TOTAL	**11058**	**3112**	**110**	**14280**	**6652**	**2416**	**94**	**9162**	**6560**	**2298(3)**	**51**	**10577**	**34019**

(1) Figures for Air Force, Army, and Navy are for commissioned officers only. Number of enlisted men with engineering degrees not reported.
(2) The Marine Corps did not provide a breakdown by field or degree. Total includes 1,668 engineering graduates, not otherwise classified, serving in the Marine Corps.
(3) Includes 64 master's degree candidates without bachelor's degree.
(4) Designated as engineering duty officers, but highest degree is in field indicated.
(5) Includes petroleum engineers in Air Force only.

NOTE: Totals for some fields are understated because of not being separately identified by one or more of the services.

the greatest emphasis on civil, mechanical, and electrical engineering. The Civil Engineering Corps is currently offering civilians with at least a bachelor's degree plus five years of experience in specified fields direct commissions as officers at grade levels commensurate with their professional competence. The CEC is a separate staff corps (like the Medical and Supply Corps) and wears a special insignia of four crossed feathers. It is the largest designated engineering career group in the Navy.

Ship Engineering

Officers in this group are designated as "restricted line" specialists. Although they are not a separate staff corps like the Civil Engineers, they are assigned throughout their career to engineering "billets" under the Naval Ship Systems Command or the Naval Electronic Systems Command. Practically all engineering specialties are needed; but the largest requirements are for naval architects, electronics engineers, and mechanical engineers. Ship engineering officers are responsible for research, ship design, management of shipbuilding and repair activities, and for handling technical operating and maintenance problems for the active fleet. Some serve as engineering officers on large ships such as aircraft carriers. With some 900 officers assigned, this group is the second largest career engineering group in the Navy. The Department of Defense has recently requested Congressional authorization to increase the numbers of officers in this and other engineering specialties.

Ordnance and Aeronautical Engineering

There are about 500 officers in these two groups. Until recently they were loosely combined as the Weapons Engineering Duty group, but with the reorganization of the Navy into specialized systems commands they have been separated again. Both groups are included in the Navy's new proposals for expansion of its engineering strength. Like the ship engineers, the OED and AED specialists are in the "restricted line" category. Their duties primarily involve technical and managerial responsibility for all aspects of the Navy's weapons systems and aircraft. Many officers in these groups have advanced degrees in ordnance engineering given under the Navy's postgraduate programs. There is no exact civilian counterpart for this degree, and it is therefore reported separately in the table on page 3.

Other Specialist Groups

Limited numbers of engineers are assigned to "special duty" groups in hydrography, aerology, and cryptology. The Supply Corps also has specific requirements for data processing, systems, textile, petroleum, and other kinds of engineers. Engineering requirements for all these groups combined total about 340 officers at the master's and doctor's degree levels.

General Line Subspecialists

The Navy defines almost 7,000 unrestricted line positions as requiring engineers with postgraduate degrees. As subspecialists, however, these officers serve primarily in traditional naval billets afloat and ashore. About one tour of duty out of every two or three will probably be in a position requiring the engineering knowledge of the officer's subspecialty.

To fill these positions the Navy has about 5,800 general line officers with engineering degrees of all kinds, but only 2,500 are designated as subspecialists in ship and weapons engineering. Since these are not enough to fill all of the engineering billets, the Navy is using officers with degrees in science or related fields to make up the difference.

Engineers in the Marine Corps

Engineering graduates in the Marine Corps are eligible for assignment to specialized career fields, which include engineering, communications, and others. A small number of non-career engineering graduates serve in fields of secondary specialization which are technical in nature. Most marines, however, are in combat-oriented positions consistent with the mission of the corps.

There are 1,668 engineering graduates in the Marines. Of these, only 171 are assigned to engineering as a primary occupational specialty. Another 65 are in communications and 16 in other technical specialties. The Marine Corps considers naval aviation and air control/anti-air warfare as technically oriented fields, and reports that 532 engineers are assigned to these areas. In addition, 67 have secondary specialties in areas mentioned above. The remaining 817 engineers are in positions with little or no technical orientation.

Summary

The 38,000 engineers in uniform are equivalent to more than a full year's output of new graduates from all the nation's engineering schools combined. They constitute perhaps 6% of the entire engineering profession. Their work is even more essential to the national defense than their numbers would indicate, because they constitute the technological manpower core without which modern armed forces could not function.

The Engineering Manpower Commission believes that the engineering profession can be proud of its record of military service. For its part, the Commission is working to assure that all engineers in the armed forces will be given every opportunity to serve in positions consistent with their skills and compatible with their professional development.

ENGINEERING MANPOWER